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Afrotherian Conservation is published once a year by the IUCN Species Survival Commission Afrotheria Specialist Group to promote the exchange of news and information on the conservation of, and applied research into, golden moles, sengis, hyraxes, tenrecs and the aardvark.

Message from the Chair

Galen Rathbun

Chair, IUCN/SSC Afrotheria Specialist Group

After the controversy over the last couple of years on the structure of specialist groups within the Species Survival Commission (SSC), I trust that you all have rightly concluded that we are still functional as we moved into the next quadrennial (2009-2012). Dr. Simon Stuart, the new Chair of the SSC, asked if I would continue as the Chair of our Afrotheria Specialist Group, which I accepted. I then made contact with our Section Co-ordinators for input as to who they would like to reappoint as members, keeping in mind our membership criteria (see page 20 in this newsletter). Based on these criteria, we made a few changes to our membership. I thank Dr. Benjamin Dudu Akaibe, Dr. Andrew Baker, Mr. Mike Griffin, Prof. Kim Howell, Prof. Jonathan Kingdon, Dr. Peter Lindsey, and Dr. Erik Seiffert for their past participation. Erik's initial assembly of our web site continues to serve us well – thanks so much for your past efforts, Erik. Dr. Hendrik Hoeck stepped down as Hyrax Section Co-ordinator, but he remains active in our group. Dr. Paulette Bloomer has agreed to take on co-ordinating hyrax activities – thanks so much, Paulette. We welcome Dr. John Hart, Dr. Patricia Holroyd, Dr. Lee Koren, Mr. Caleb Boateng Ofori and Dr. Francesco

Rovero as new members of our group. To find out more about their affiliations and expertise, and the structure of our group, visit the membership section of our web site.

Speaking of our web site, see the notice on page 19 regarding our new web site address or URL.

As for our newsletter, editor Dr. PJ Stephenson continues to do an excellent job (thank you so much, PJ), including his recent assessment of the newsletter. The full report can be found on our web site by going to the newsletter section. In addition, a summary of the report is found in this issue of our newsletter (page 19). As you will see, there were many excellent suggestions to further improve this publication, and I want to comment on a couple of topics that came up in the assessment.

As most of our members realize, our web site and newsletter exist because of volunteer time – thus the continued success and quality of these windows into our group will largely be determined by volunteers and their contributions. Therefore, please keep up the good work and continue to reach out to your colleagues for newsletter contributions.

It was suggested that we might get support for our newsletter from IUCN headquarters. Although this would seem to be an obvious source of financial help, this is in reality not realistic. IUCN mostly provides us the structure to exist, “moral support”, and administrative information and co-ordination. This is largely because the SSC's more than 100 specialist groups and task forces are mostly composed of highly motivated and generous volunteers.

IUCN periodically provides us with a list of organizations that accept applications for financial support. The criteria and frequency of these opportunities are quite varied and it is tough to compete with the “charismatic mega-fauna” for attention and funding. I will continue to email these communications from IUCN to our group members, and we will strive to include more information on funding opportunities in our newsletter. Our golden mole and sengi biologists have had some past success in obtaining outside funding (see reports in this issue by Sarita Maree on golden moles and Francesco Rovero on sengis) with endorsement from our specialist group. So please let me know if you are interested in pursuing any of these opportunities.

On the research front, check out the Bibliography and Abstracts sections in this issue of the newsletter, especially the paper describing a new species of tenrec (page 21). It is also personally very satisfying to see “sengi” incorporated into the name of the new genus *Miosengi* (Grossman & Holyroyd 2009) – and yes, we are interested in the diversity of long-extinct forms, as represented by fossils!

G.B. Rathbun

Cambria, California. 1 December 2009

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Species Profile

The common tenrec, *Tenrec ecaudatus*

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The common tenrec (*Tenrec ecaudatus*) is the largest and most widespread of Madagascar's tenrecs (Lipotyphla: Tenrecidae) in the sub-family Tenrecinae. Its relatively large size of 1-2 kg or more means that it is widely hunted in Madagascar (Nicoll & Rathbun 1990, Nicoll 2003). It has been deliberately introduced to neighbouring islands as a food source and has even been farmed.

Like all tenrecs, this species exhibits a number of characteristics that are believed to be typical of early eutherian mammals. These include the retention of a common uro-genital opening or cloaca, abdominal testes, weak eyesight and a dependence on smell and hearing, relatively low body temperature and metabolic rate, and nocturnal activity patterns. Wild-caught body mass ranges from 600-1,200 g when animals are leanest at the end of the breeding season, but can almost double when autumnal fattening is complete. Head-body length is 25-32 cm and the tail 1.0-1.5 cm. Females are smaller than males. The adult pelage is coarse with long guard hairs. Spines are common with the greatest concentration on the nape and head but individuals become less spiny with age. Many spines are barbed. Adult females are dark tan to brown on the upperside while males are noticeably paler due to a wide cream-coloured band and pale tips on the hairs. The underside has sparse short creamy hairs. Juveniles have longitudinal black and cream bands that are lost at the first moult in roughly 45 days. Young animals are noticeably spiny and have a concentration of rigid spines in the central dorsal stripe that can be rubbed together to produce ultrasound. This stridulating organ and the striped colouration are features shared by two closely-related streaked tenrecs (*Hemicentetes*) which retain striped colouration and stridulation into adulthood, whereas adult *T. ecaudatus* does not. Common tenrecs have a wide gape and adult males develop massive biting musculature, giving them a somewhat bulbous head. When adult, males also develop a thick dermal pad used in defence when fighting over oestrus females (Nicoll 1982).

Tenrec ecaudatus occurs throughout Madagascar's diverse natural terrestrial habitats ranging from humid evergreen forest in the east through western seasonal forests and the southern arid spiny and succulent bush (Gould & Eisenberg 1966, Eisenberg & Gould 1970, Nicoll & Langrand 1989, Garbutt 1999). It adapts readily to modified habitats such as farmland and forest plantations as long as cover is adequate, and occurs in some of the larger cities. The tenrec is common in the Comoros Archipelago but whether this is a result of deliberate introduction or natural colonization is not clear. This species was deliberately introduced to the Mascarene Islands as a food source and was later introduced to the larger Seychelles around 1880 (Nicoll

1982). Animals are still hunted in the Comoros and the Mascarenes but not in the Seychelles where adult densities can reach a remarkable 15/ha in favourable habitats (Nicoll 1985).



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Figure 1. A pair of common tenrecs.

Tenrecs are generally solitary but male-female pairs occur 1-3 days during the mating season. Individuals rest in natural or excavated burrows up to 150cm long often under tree roots, rocks and fallen logs. Tenrecs will occupy a number of burrows and through a given period a single site may be occupied by different individuals. Tenrecs are largely nocturnal, but during late pregnancy and lactation females forage regularly throughout the day and night (Nicoll 1983). The young accompany her at around the age of 19 days and continue to forage at any time of day or night in small groups from weaning until their first moult at 35-70 days. The shared striped colouration and stridulation by juvenile *T. ecaudatus* and *Hemicentetes* indicate a common ancestry and perhaps a degree of crypsis when foraging in daylight, especially as *H. semispinosus* is also partly diurnal.

Tenrec ecaudatus is terrestrial and feeds on a wide range of invertebrates and small vertebrates, seeking them in the soil, leaf-litter and rotting wood. Fruit is also eaten, especially late in the summer active season when individuals are fattening for obligate hibernation. This species is highly heterothermic, undergoing a six-month winter hibernation in a plugged burrow when food supplies are lowest. At this time fat may constitute almost 50% of body mass. Hibernating animals maintain body temperatures close to ambient except for a short rise of 1-2°C in early evening (Nicoll 1986). Captive hibernating tenrecs remained in the same burrow for the entire period but animals may revive briefly to seek alternative burrows when heavy rains cause flooding. Summer foraging or other activities are accompanied by a rise in body temperatures to 34.0-35.5°C, with sexually active males having the lowest. When resting, temperatures fall progressively towards ambient although pregnant females appear to have a low threshold of about 23°C, regardless of surrounding temperatures. Torpor is linked to a tight energy budget (Nicoll 1982, 1985).

In Madagascar tenrecs mate during September and October with perhaps some variation based on regional climate regimes, but they breed about one month earlier in the more tropical Seychelles. Fighting between males is common at this time and wounds inflicted by the long canines can be found on the thick dermal pad. Coitus can last up to 25 minutes. Gestation length appears to vary but averages 60 days (Eisenberg &

Gould 1970), with the variation probably linked to female daily torpor and slowed foetal growth, a phenomenon known among heterothermic bats and at least one tenrecs species (Stephenson 1993). Peak births in Madagascar occur in January but are one month earlier in the Seychelles. Litters are typically large with a recorded high of 32, one of the highest among mammals. Museum records indicate that animals in the seasonally dry west and south of Madagascar have the largest litters while field studies in the Seychelles show that litter size there is lower, peaking at 18-20. Polyovular ovarian follicles are common with up to five ovules in a single follicle. *T. ecaudatus* is also unusual in that the follicles do not fill with fluid to form a typical Graafian follicle. Instead, the solid follicles rupture slowly and the ovules 'migrate' to the surface where intrafollicular fertilization occurs (Nicoll & Racey 1985). First year adult females consistently have the largest litters in the Seychelles. By the third breeding season litter size is considerably reduced through lower ovulation rates and intrauterine mortality or foetal resorption. Few females, if any, appear to survive or breed during a fourth season.

Malagasy *T. ecaudatus* is predated by owls and the island's endemic carnivores (Garbutt 1999). Tenrecs are also widely hunted in Madagascar, hunters often using dogs to locate them. Hunting pressure can be intense and local extinction near large cities appears to have occurred. However, a WWF survey of Malagasy protected areas (Nicoll & Langrand 1989) showed that the common tenrec occurs in most – if not all – protected areas. It readily adapts to anthropogenic habitats and is not significantly threatened (Nicoll & Rathbun 1990). The introduced Mascarene populations have historically been hunted but on Mauritius at least this practice appears to be declining. In the Islamic Comoros tenrec hunting has long been taboo but recent observations indicate that small numbers are now harvested during the active summer months.



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Figure 2. A common tenrec foraging for invertebrates.

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Scientific Articles

Past records of *Elephantulus* and *Macroscelides*: geographic and taxonomic issues

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Introduction

The molecular phylogenetics of extant sengis (Order Macroscelidea; Family Macroscelididae) are increasingly well documented (Douady *et al.* 2003, Smit *et al.* 2007, 2008) and has led to novel observations, from the recognition of new species that likely arose due to geographic factors (*Elephantulus pilicaudus*, Smit *et al.* 2007, 2008) to the suggestion of new clades (*Petrodromus*+*Elephantulus rozeti*) with very old divergence times (> 11 million years) for living species pairs. Ongoing work on *Macroscelides* also suggests this genus may not be monospecific (G. Rathbun, personal observation and H. Smit and J. Dumbacher, personal communication, cited in Rathbun 2009). These recent and ongoing studies give us a template for better understanding the evolutionary history of the living sengis, but are only one line of evidence that can be used for testing newly-generated hypotheses.

Several years ago I was invited to write a short review chapter on the systematics and fossil distribution of Macroscelidea (Holroyd in press) to update Butler's classic 1995 review. I was surprised to discover that while the deep time fossil record of sengis (i.e. from approximately 50-15 million years ago) was well documented in many articles and monographic studies, the more recent record of the group was comparatively less well-studied. Records of fossil *Elephantulus* and *Macroscelides* species appear in many faunal lists for sites throughout southern Africa (Figure 1), but this record had not been pulled together to see what patterns emerged. My aim here is to briefly review the Pliocene to Pleistocene (approximately 5.3 million years ago [Ma] to 100 thousand years ago [ka]) fossil record of sengis in southern and eastern Africa, offer some preliminary observations that arise from this compilation, and highlight areas for future research. Ages of sites follows Werdelin (in press). The fossil record represents a unique set of data that can provide insights relevant to better understanding the phylogeny and biogeography of the extant sengis, for testing hypotheses that suggest very old divergences of living species lineages, and most critically, for how we may anticipate that sengi ranges will shift with future climate change. The fossil record is still not well integrated into conservation biology, but is relevant for many aspects of modern species assessment and management, such as ground-truthing bioclimatic species models and accurately recognizing invasive species (versus those re-occupying prior ranges) (Willis & Birks, 2006).

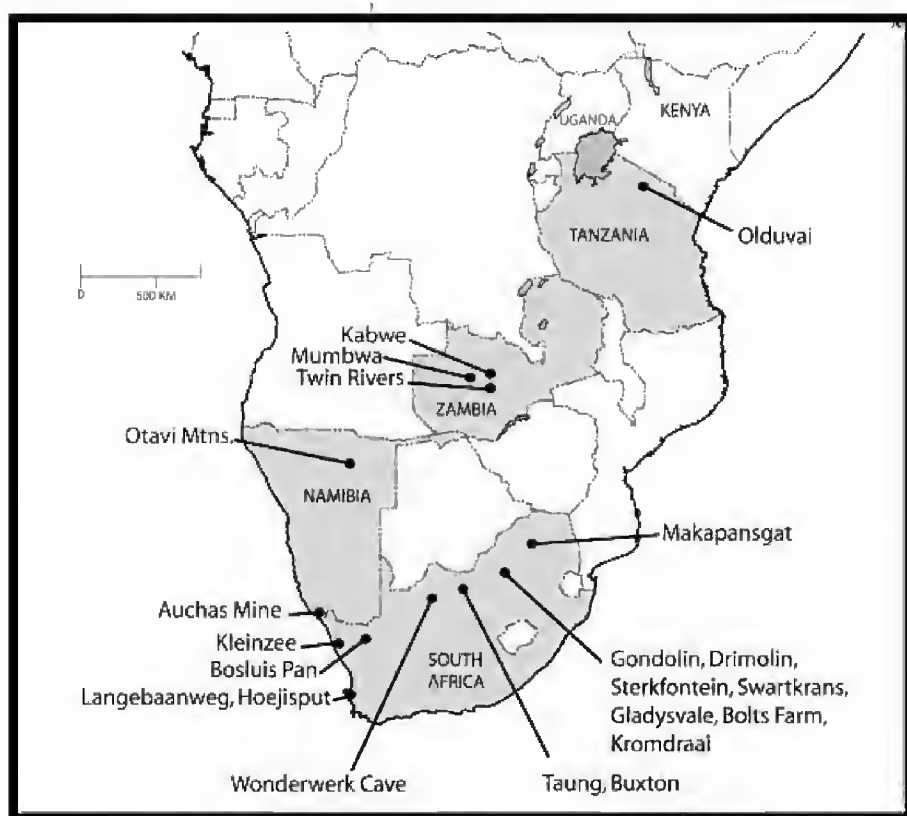


Figure 1. Map showing fossil localities where *Elephantulus* or *Macroscelides* fossils have been found; map after Holroyd (in press).

The Macroscelidine Fossil Record

Macroscelidines as a subfamily are first recognized in the early Miocene of Kenya: *Miosengi butleri* at 17.5-16.8 Ma (Grossman & Holroyd 2009), *Pronasilio ternanensis* at 14.2 Ma (Butler 1984), and possibly *Hivegicyon juvenalis* at 14.2 Ma (Butler 1984). There is then a vast temporal and geographic gap in their known occurrences, until approximately 5 Ma at Langebaanweg in westernmost Cape Province, where *Elephantulus* sp. indet. has been

reported in faunal lists (Hendey 1981), indicating that the living genus had certainly arisen by that time.

The next oldest, and best documented, sengis are from Makapansgat in northeastern South Africa (Butler & Greenwood 1976, Pocock 1987), which are typically dated to approximately 3 Ma, and is the first in a succession of fossil-rich cave faunas distributed across the northern part of South Africa that have been intensively investigated for early hominids. Four species of sengi have been described from Makapansgat: *Elephantulus antiquus*, a relatively large extinct species; *E. broomi*, a small extinct species that may be close to *E. intufi* and *E. fuscus*; *E. fuscus leakeyi*, a subspecies of extant *E. fuscus*, and *Macroscelides proboscideus vagus*, a subspecies of the living species. These fossils occur as part of rich mammal assemblages in cave deposits that primarily represent owl or other bird accumulations. Most came from isolated karst blocks removed during quarrying activities (see discussion in Pocock 1987). The Makapansgat sengis are notable for a variety of reasons. These are the only fossil specimens of Plio-Pleistocene age in southern Africa that have been formally described and illustrated since the description of the types in the 1930's; all other site records are only known from faunal lists. It also has the highest sengi diversity of any paleontological site. This in part may be due to these fossil assemblages representing hundreds to thousands of years of accumulation, or may be an effect of very large sample size. To date, a minimum of 250 individual sengis have been recovered from the pink breccias of Makapansgat and continued processing of a single breccia block housed at the University of Colorado has yielded hundreds more teeth and postcrania of sengis (P. Holroyd, personal observation), making it likely this is one of the richest micromammal sites of this age.

The most common species at Makapansgat is *Elephantulus antiquus*, and it has also been reported from late Pliocene to early Pleistocene sites across northern South Africa (Bolt's Farm, Buxton Limeworks, Gladysvale, Swartkrans, Sterkfontein, Kromdraai A & B) and may have persisted as late as 1.5 Ma (Pocock 1987, Butler 1995).

Fossils assigned to extant sengi species are somewhat less common, and only those assigned to the extinct subspecies *Elephantulus fuscus leakeyi* and *Macroscelides proboscideus vagans* have been formally described. Otherwise, all reports are from faunal lists. These records are summarized in Figure 2a-c. As the figures make clear, most of the fossil occurrences are near the edges of the extant ranges or well outside them.

Living *Elephantulus brachyrhynchus* has a very broad geographic distribution (Figure 2A). Fossil specimens assigned to *Elephantulus* cf. *brachyrhynchus* (cf. meaning "near but not identical with") are known from Kromdraai B, Sterkfontein, and Makapansgat (Pocock 1987), although Pocock's Makapansgat records may be the morph that Butler and Greenwood (1976) assigned to *E. broomi* or *E. fuscus leakeyi*. Fossils definitely assigned to the modern species are known from a series of sites in Zambia: Kabwe (1.33 Ma to 780 ka), Mumbwa (194-124 ka) and Twin Rivers (266-140 ka) (Avery 2003). Avery (2003:53) notes, however, that the Kabwe sample was assigned to *E. brachyrhynchus* "pending confirmation of the presence of an extralimital species", suggesting it may represent some other taxon. None of these fossils have been described or illustrated, so reinvestigation could

potentially shed light on when *E. brachyrhynchus* proper first appears in the fossil record.

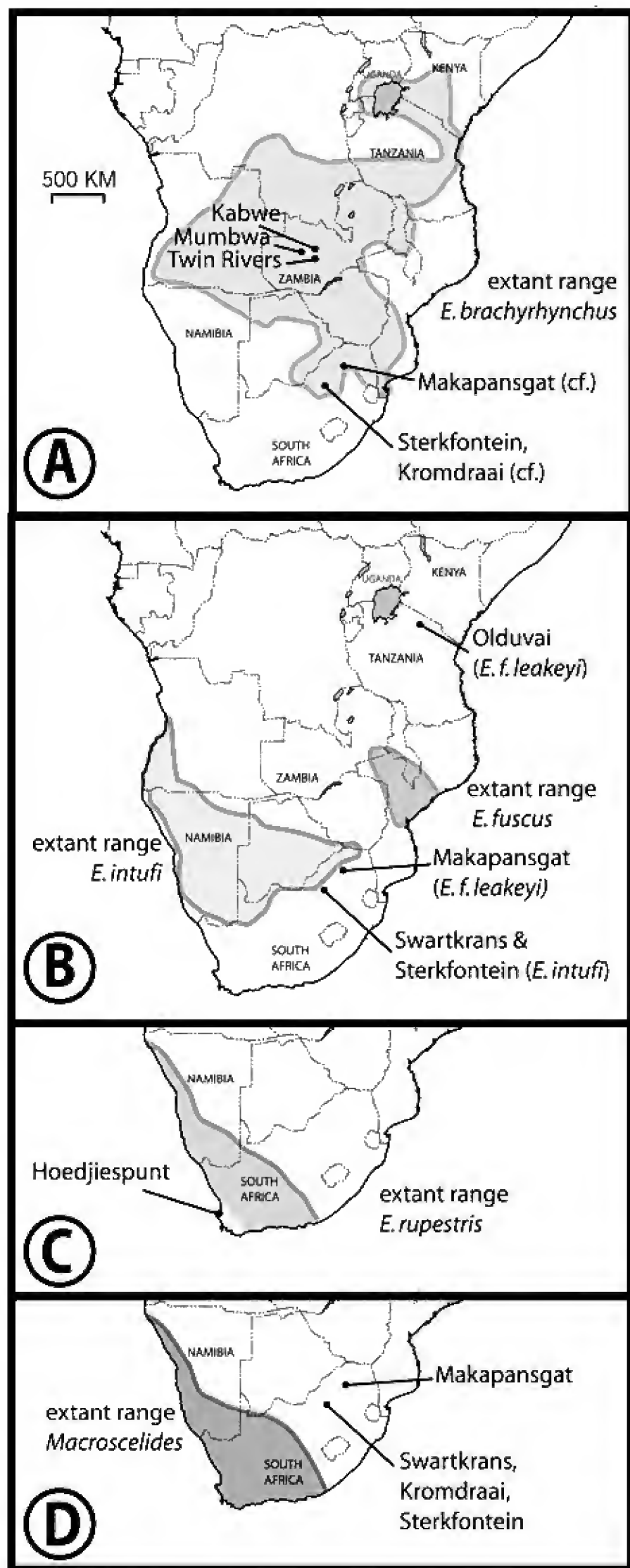


Figure 2. Maps of modern sengi distribution and fossils attributed to extant species; fossil occurrences after Holroyd (in press); modern distributions after Rathbun and Nyari (2009). **A.** Distribution of *Elephantulus brachyrhynchus* and fossil sites with records of *E. cf. brachyrhynchus* and *E. brachyrhynchus*. **B.** Distribution of *E. intufi*, *E. fuscus* and *E. fuscus leakeyi*. **C.** Distribution of *E. rupestris*. **D.** Distribution of living and fossil *Macroscelides*.

Elephantulus fuscus leakeyi has the most anomalous distribution (Figure 2B). The subspecies was originally described from Olduvai in northern Tanzania (Butler &

Greenwood 1976), now regarded as between 1.87 and 0.6 Ma in age. Both records are well outside the modern range of *E. fuscus*; the Makapansgat records are approximately 500 km southwest of the modern range and those from Olduvai are more than 1200 km to the north. The taxonomic status of these fossils is further complicated by the fact that the Olduvai sengis cannot now be located, and our knowledge of this subspecies must be based largely on the handful of specimens from Makapansgat, which are probably much older. Butler and Greenwood (1976) discussed the morphology of the fossils in great detail, noting that they also share many characteristics with *E. brachyrhynchus*, but were more similar to *E. fuscus*. Restudy of the Makapansgat specimens will be necessary to determine whether *E. fuscus* had a wider geographic range in the past, or whether something morphologically close to living *E. fuscus* represents ancestral characters for a broader clade including *E. brachyrhynchus* (Butler & Greenwood 1976).

Elephantulus intufi fossils are recorded from Swartkrans Members 1 and 3 and the Achulean levels of Sterkfontein Member 5, approximately 2-1.5 Ma (Avery 2001) (Figure 1B). These sites are only slightly outside the modern distribution, and it is plausible that it ranged more widely during periods of drier climate. Fossils of *Elephantulus rupestris* from Hoedjiespunt 1 (Figure 2C) place it at 200-300 ka and range up to 13,600-300 years BP at Elands Bay (Matthews *et al.* 2005, 2007). These records are within the area where *E. edwardii* occurs today and, as noted by Matthews *et al.* (2005), approximately 250 km south of the extant range of *E. rupestris* (as is the case for other small mammals from these sites). These records suggest a range contraction or shift of *E. rupestris* within recent times. *E. edwardii* is only known from a 15.5 ka old record at Saldanha Bay Yacht Club site on the Hoedjiespunt Peninsula (Matthews *et al.* 2007), within its current distribution.

Macroscelides possibly has the most intriguing of fossil distributions, because its entire fossil record occurs more than 500 km outside the current range (Figure 2D). Unlike the records of *E. fuscus* discussed above, these fossils can't potentially be reinterpreted as being from a related lineage known from the area today. The oldest fossil is the subspecies *M. proboscideus vagans*, described by Butler and Greenwood (1976) from Makapansgat at 3.5-2.5 Ma. Pocock (1987) discussed additional specimens from Kromdraai B (ca. 1.9-1.6 Ma) and noted that these showed the lack of a distinct metaconid on the third premolar and suggested that it and the Makapansgat specimens be regarded as distinct species. Pocock (1987) also reported specimens from Sterkfontein (ca. 1.7 Ma) that were 25% larger and could not be distinguished from *M. proboscideus*. My preliminary analyses of the Makapansgat *Macroscelides* sample confirms that it is generally smaller, has lower tooth crowns, and is shorter snouted than most, but not all, living *M. proboscideus*. Further comparisons of *M. proboscideus* across its entire range are needed in order to make an informed taxonomic decision on species vs. subspecies status. In addition to documenting a much wider geographic range in the past, the fossil record suggests that it was long-lasting. Avery (2001) found *M. proboscideus* from multiple stratigraphic levels at Sterkfontein and Swartkrans, indicating that *Macroscelides* was present in the Sterkfontein Valley from ca. 1.7 Ma to as recently as less than 100,000 years ago.

There are also reports of unidentified sengis from additional sites in South Africa (Wonderwerk Cave, Avery 2007) and Namibia (Plio-Pleistocene Kaokoland karsts, late Pleistocene sites in the Otavi Mountains, Pickford & Senut 2002) and Plio-Pleistocene caves in southern Angola (Pickford *et al.* 1992) (see Figure 3). Additional reports of *Elephantulus* sp. are also known from the sites of Drimolin (2-1.5 Ma) and Gondolin (1.9-1.5 Ma) in the Sterkfontein Valley (Sénégas *et al.* 2005). Further analysis and description of these (especially those from Namibia and Angola) could provide key data for the species that currently live in these areas.

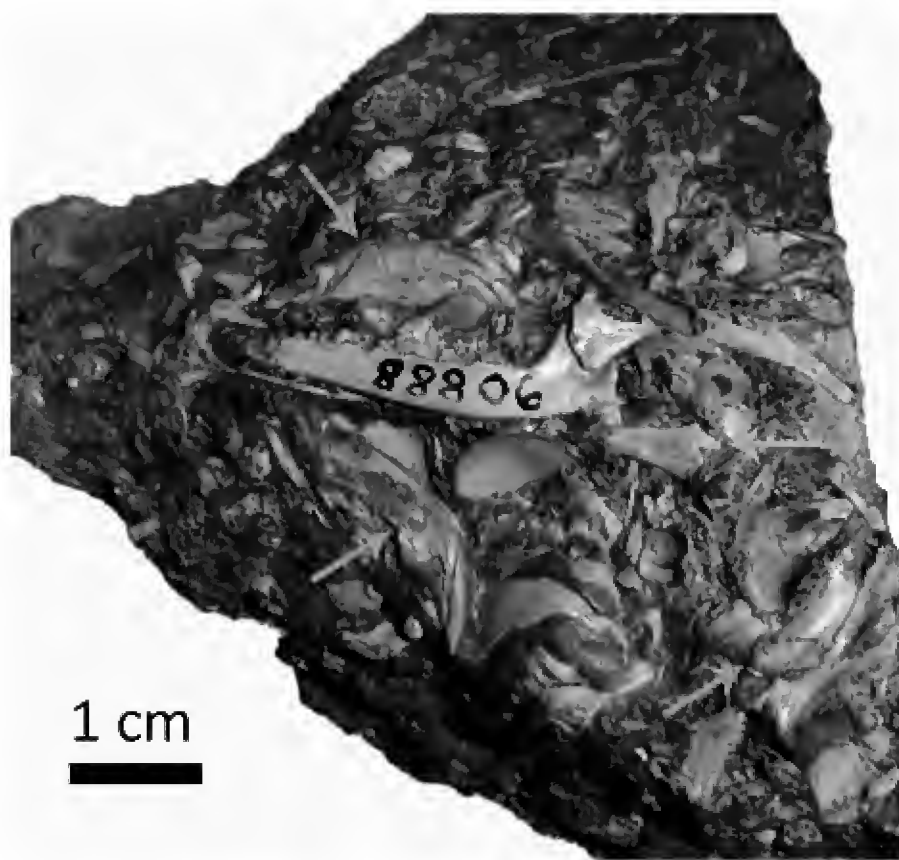


Figure 3. A yet-to-be described lower jaw of *Elephantulus* from Gladysvale Cave, embedded in bone-rich breccia that includes at least 3 rodent jaws (blue arrows) and a sengi partial limb bone (yellow arrow). From the University of California Museum of Paleontology collection.

Conclusions

The sengi fossil record represents a rich, untapped resource for better understanding the morphological and biogeographic evolution of the lineages of living sengis. If the ancient divergences suggested by molecular clock studies (Douady *et al.* 2003) are even close to accurate, it highlights the importance of trying to better document and expand upon the fossil records of the living genera and species to better understand their past geographic ranges and understand their diversification. Phylogeographic studies of South Africa's faunas are increasingly common (see Daniels *et al.* 2009 for a good discussion), but it is key to be able to incorporate past ranges into such studies, particularly in such an ecologically complex landscape. To date, the Plio-Pleistocene fossil record of sengis has primarily been studied for its value in interpreting paleoecology and taphonomy (see e.g. Avery 2003, Matthews *et al.* 2005, 2007, Sénégas *et al.* 2005); i.e., the presence or absence of certain species of sengis has been used to infer the presence of their preferred habitats in or near these fossil sites.

While paleoecologists look at the sengi fossil record as a way to interpret past habitats, we can also use those same data to hypothesize where sengis may range

in the future. Even a brief review such as this one demonstrates that many of the oldest records of living sengi lineages lie outside their modern ranges and that these species may have been long established in some areas. Even archeological sites may demonstrate significant sengi range changes, or at least that of humans interested in them (Rathbun 2008). The fossil and archeological records of sengis, and that of other small-bodied fauna found in these sites, clearly need to be evaluated in greater detail. Extra-limital records are certainly to be expected as climatic change shifted biomes through the Pliocene and Pleistocene. Similarly, we can certainly expect to see range changes due to human-induced changes to the climate and landscape. A more focused examination of the fossil record holds great potential to provide data directly relevant to understanding potential future range changes, as they demonstrate how sengis have responded to periods of aridification and climatic cooling and warming in the past.

Acknowledgments

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Habitat ecology of aardvarks (*Orycteropus afer*) in Bui National Park, Ghana

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Abstract

We present a preliminary assessment of the distribution and habitat associations of the aardvark (*Orycteropus afer*) in Bui National Park, Ghana, where the species is threatened by ongoing hydro-electric dam construction. We used key informants interviews and questionnaires to determine the historical distribution of aardvarks in the park and a stratified random-design for ecological data gathering on standardized strip transects. Several parallel transects were laid at 50 m intervals tangential to the Black Volta River to determine the possible association of aardvarks with watercourses and preferences for either riverine or savanna habitats. Burrows were used as indicators for aardvark distribution. Results provide evidence of a viable population of aardvarks in the park with higher burrow densities in riverine habitat than in savanna habitat, burrows generally being distributed at safe distances (150 ± 25 m) from the Black Volta River. This may be linked to prey abundance. We conclude that aardvark population of the park will be severely affected by the construction of the Bui dam and management interventions are urgently required to save this population from local extinction.

Introduction

The aardvark (*Orycteropus afer*) (Figure 1) is distributed throughout sub-Saharan Africa (Lindsey *et al.* 2008). They are known to feed primarily on ants, but termites also constitute an important part of their diet (Melton & Daniels 1986, Willis *et al.* 1992, Taylor *et al.* 2002). Because many animals (from invertebrates to mammals) use their burrows, the aardvark is often considered a keystone species (Cilliers 2002). Additionally, it plays a vital role as a seed dispersal agent for several wild fruits (e.g. *Cucumis humifructus*) and as a key link in ecosystem food chains (Kingdon 1974, Milton & Dean 2001). However, the species is poorly studied in many areas, especially in west Africa. The aardvark has been on and off the lists of threatened species due to lack of precise information on its distribution and regional status. It is currently considered of Least Concern in the IUCN Red List and was deleted from CITES Appendix II in 1992 (Lindsey *et al.* 2008, UNEP-WCMC 2009). The paucity of information on the species makes the need for, and development of, specific management interventions extremely difficult at both local and regional levels. Hence, a robust assessment of the presence and distribution of the aardvark is urgently needed.



Figure 1. A female aardvark photographed in Mole National Park, Ghana. Photo credit Cole Burton (University of California, Berkeley) and the Ghana Wildlife Division

No study has yet been published on the aardvarks of Ghana. The aardvark is listed in the first schedule of the Ghana wildlife conservation act as one of the animals of prime conservation concern (Vivian 2002). It is generally believed that aardvarks were very abundant over two decades ago in the Bui National Park (Bui NP) and its environs, where they still hold traditional, sacred value as totem animals. However, the current status of the aardvark in Bui NP is unknown and unconfirmed reports indicate that the species is feared threatened or locally extinct in some areas. It is conspicuously missing on the Bui NP species list and has not been mentioned in park management strategies for over twenty-five years.

The objective of the present study was to confirm the presence, distribution and habitat associations of aardvarks in Bui NP.

Methods

The study was carried out between April and July 2005 in Bui National Park (8°00'-8°25'N, 2°15'-2°30'W), the third largest park in Ghana, with a total land area of 307,360 ha. The park comprises forest and savanna habitats in undulating catchments of small tributaries of the Black Volta River, which roughly bisects the park.

We used burrow surveys as an indirect census technique to provide information on the distribution and activity of the aardvark in Bui NP. Shoshani *et al.* (1988) classified aardvark burrows into three main types: 1. Temporary holes that are made by the aardvark when searching for food; 2. Semi-permanent burrows that are made to serve as refuge sites when alarmed; 3. Extensive and permanent burrows in which the young are born. In this study all analyses were based on the third category, permanent burrows. These were at least 100 cm wide with a mass of earth behind the burrows showing signs of recent activity such as tail markings and footprints.

Key informant interviews were conducted among retired wildlife staff and hunters to determine aardvark distribution. Respondents were selected based on their period of stay in the park and relevant field experiences. Based on information generated by the interviews, burrows were located in the park by repeated field visits. We recorded the geographic position of each permanent burrow using a handheld GPS receiver (Etrex).

To investigate the densities and distribution of burrows with respect to vegetation types we stratified the

study site based on the two dominant vegetation types (forest and savanna). The forest was further divided into disturbed and undisturbed whilst the savanna was divided into savanna woodland and mountainous areas. Each transect was one kilometre in length. On each transect, the length along transect at which a burrow was sighted and the corresponding perpendicular distances (offset) were recorded.

To determine the relationship between aardvark burrows and watercourses, eight transects were laid parallel to the river course and separated from each other by an incremental distance of 50 m. On each transect, the length along the transect at which a burrow was sighted and the corresponding perpendicular distances were recorded. Only burrows within 25 m to the left or right of transects were recorded.

GPS location data were processed using the ArcGis software to produce a distribution map of aardvark burrows based on vegetation types in the southern portion of the park. The densities of burrows on each transect and for each stratified zone were calculated using the programme Distance.

The burrow abundance data were limited in size and did not follow a normal distribution. Hence, we used a non-parametric test (Mann-Whitney U- test) to test the significance of the observed differences between burrow densities in the savanna and forest.

The number of burrows per transect were correlated with the perpendicular distance from the water source and plotted on a graph to evaluate the relationship between the watercourse and the species distribution.

Results

Presence of aardvarks in Bui National Park

About 92.8% (52) of all interview respondents were familiar with aardvarks. A majority (92%) of them could also identify aardvark burrows. Almost all respondents (95.2%) interviewed had seen an aardvark or its burrow at least once. Others (64.9%) claimed there were remnants of aardvark burrows on farmland. However, a greater percentage (98.1%) of the people mentioned that burrows are currently rare and impossible to see in areas outside the park.

Our field visits confirmed the presence of aardvarks in Bui NP. We recorded thirty-two (32) permanent burrows (Figure 2). There were 100+ inactive burrows (or aardvark holes) observed. Other indirect signs like footprints, tail-markings and feces were also sighted.

Burrow density

Aardvark burrows varied in density between vegetation types suggesting aardvarks in Bui NP were more concentrated in the riverine than the savanna environment ($W = 21$, $p\text{-value} = 0.0132$).

Splitting the riverine data into disturbed and undisturbed forest type further showed that the disturbed riverine forest recorded a higher density of burrows (1138.8/km²) than the undisturbed riverine forest vegetation (150/km²) (Table 1). No burrows were recorded in the mountainous area although other indirect signs such as footprints and feeding signs were encountered on several occasions in this habitat type. In both vegetation zones aardvarks preferred burrowing under a cluster of between 5 and 10 trees or shrubs.

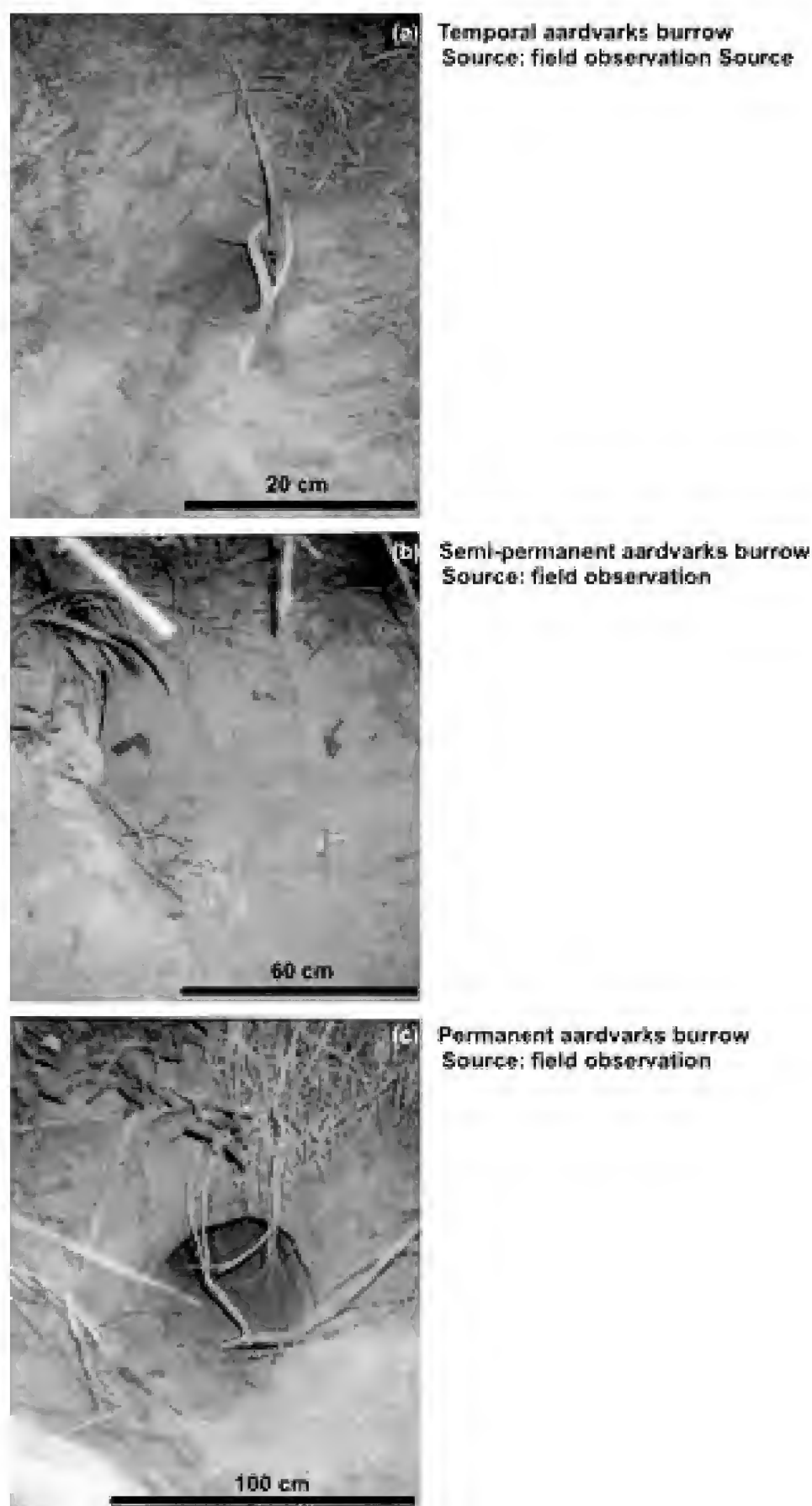


Figure 2. Different types of aardvark burrows observed in Bui National Park

Distribution

The distribution of burrows did not follow a clear pattern and appeared random within the various vegetation

zones. Whenever burrows were sighted they were densely concentrated within a particular area. This close proximity of burrows resulted in the superimposition of some burrows on others in the distribution map (Figure 4). No permanent burrows were found in both the riverine environment directly adjacent to the river (within 50m) and the mountainous areas, although footprints and feeding activities were quite pronounced. On two occasions however, it was observed that aardvarks had dug small holes that were gradually being filled up by underground water at a distance from the river of about 25 m. Local guides suggested these burrows may be used by aardvarks as drinking holes.

Relationship between aardvark burrows and watercourses

The distribution of aardvark burrows shows a strong relationship as indicated by a high co-efficient of correlation ($R=0.8364$) with the Black Volta River that bisects the park (Figure 3). This association is not linear but polynomial. The burrows located closest to the Black Volta River (27.3% of the burrows) are still 100 ± 25 m away from the riverbed whereas the farthest burrows (18.2%) are situated 200 ± 25 m away from it. Most of the burrows (54.5%) however, are distributed at a distance of 150 ± 25 m from the riverbed (Figure 3). No burrows were recorded within 50m and beyond 250 m of the riverbed.

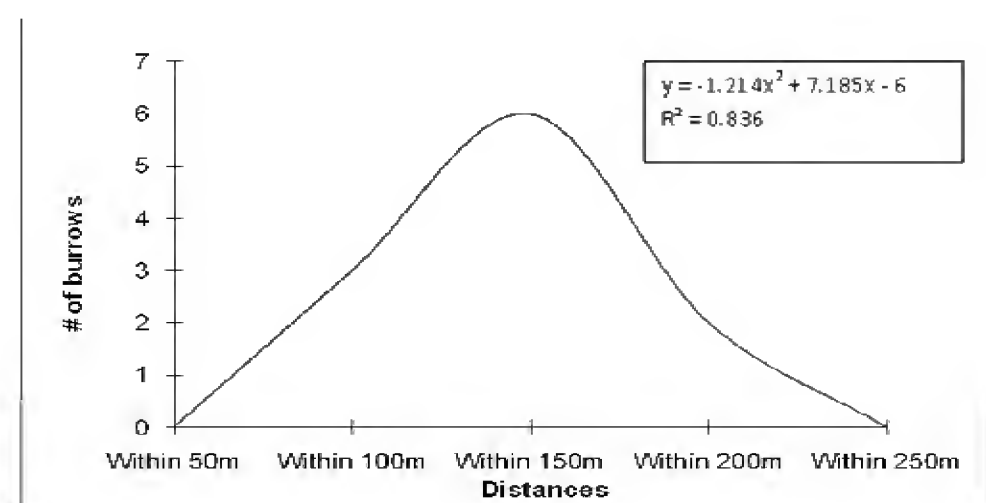


Figure 3. Distribution of aardvark burrows from the Black Volta River in Bui National Park. Burrows follow a normal distribution with peak abundance within 150m of the river.

Table 1. Density of aardvark burrows within the various vegetation types

Vegetation types	No. transects	No. burrows	Density estimates (km ²)	Coefficient of variation (%)	Confidence limits	
					Lower	Upper
Disturbed riverine forest	2	22	1138.8	38.8	529.8	1747.8
Undisturbed riverine forest	2	3	150.0	57.7	27.2	273.8
Savanna woodland	2	7	233.3	37.8	37.8	428.9
Mountainous areas	2	0	0	—	—	—

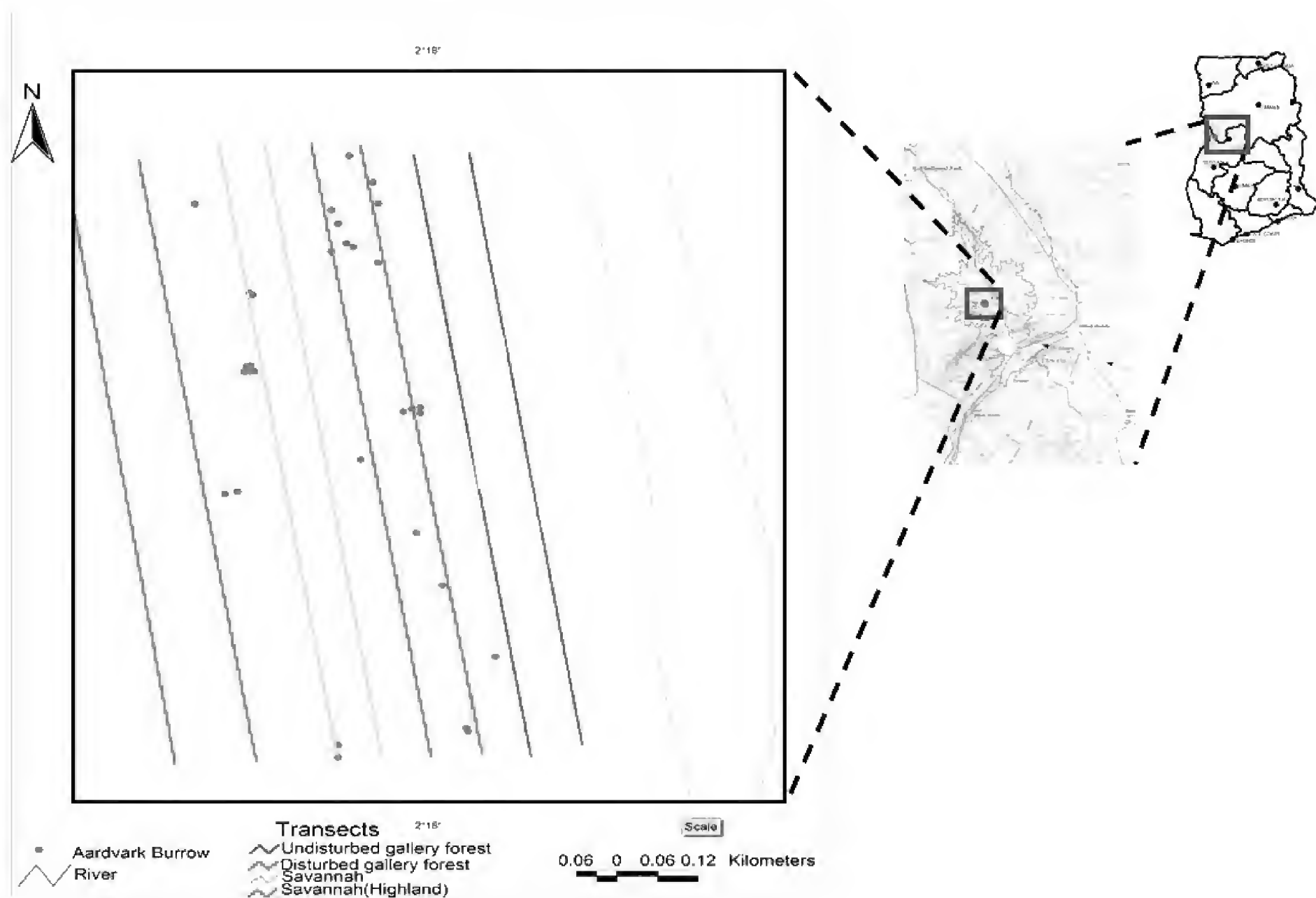


Figure 4. Map showing the distribution of burrows along forest and savanna transects. Forest transects are in green (dark green for undisturbed light green for disturbed) and Savanna transects are in purple and yellow for savanna woodland and mountainous areas respectively.

Discussion

This study found evidence of a viable population of armadillos in Bui National Park. The results of semi-formal interviews with local people suggested armadillos have decreased in abundance over the past 35 years. This decrease is correlated with an increase in human populations around the park. From 2000, several communities moved into the park from Côte d'Ivoire as a result of the civil war. This might have had an impact on the faunal communities in the park, and may explain possible reductions in the armadillo population.

We recorded a significant difference in burrow densities between the riverine forest and savanna vegetation types with armadillo activities more pronounced in the riverine environment. Our results imply that armadillos have a higher preference for gallery forest habitats than savanna habitats. Three reasons may explain this phenomenon. Firstly, riverine forests provide a moist soil that probably makes burrowing much easier. However, we observed in the riverine forest that the extensive tree root systems significantly impeded burrowing; many burrows were abandoned midway by the armadillos. A second possible reason is that armadillos preferred the riverine forest as they are hunted less there. In Bui NP, during the dry season, bushfires are rife and deprive the savannas of vegetation cover which in turn would enable hunters to locate and trap armadillos easily. A third reason might be that armadillos generally prefer riverine vegetation because of its proximity to a water source and hence the ease of finding drinking water and prey items (see below).

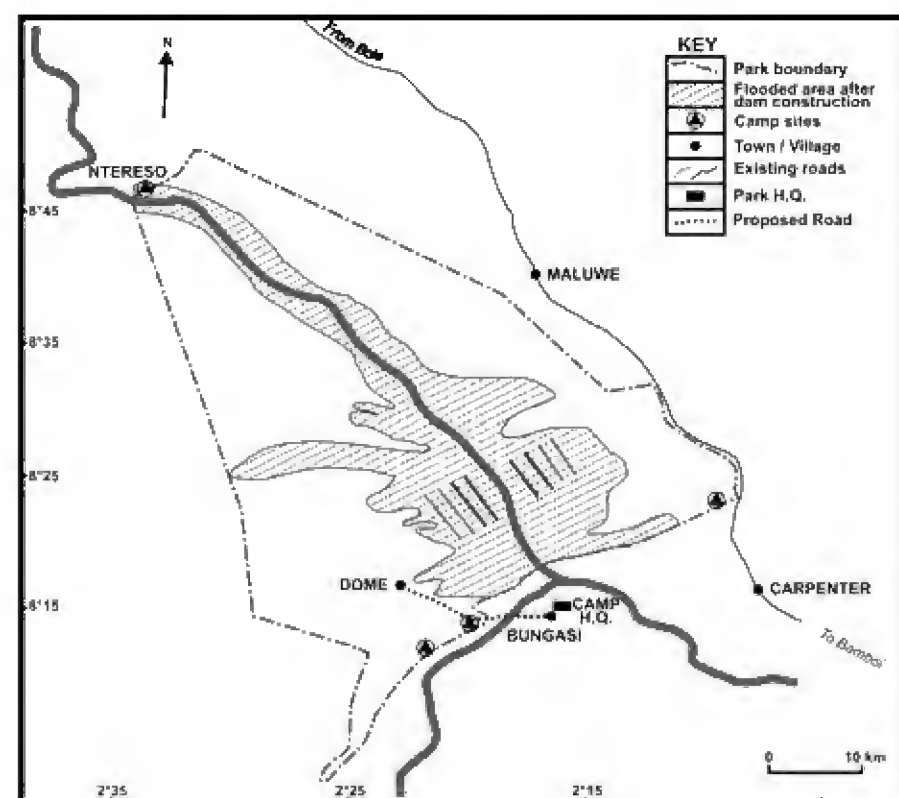


Figure 5: Map of the study site showing the predicted area to be flooded after construction of the Bui Dam (stripped area). The Black Volta River is highlighted blue and the location of transects are labelled green (forest transects) and pink (for savanna transects). Source: Ghana Wildlife Division Data Analysis.

Whatever the reason for the higher density of armadillos in gallery forest, the present study provides evidence that armadillo distribution is partly influenced by the presence or absence of water sources, and the animals seem to burrow a 'safe' distance from the river (mostly within

150±25 m) to reduce the likelihood of flooding, as suggested by Shoshani *et al.* (1988) and Brown (1997). The proximity of burrows to watercourses may also be explained by the availability of prey items. Levins and Winsor (1984) demonstrated that ant and arthropod populations preferred wetter microhabitats as opposed to drier ones in Neotropical ecosystems. In the course of the present study, we observed more termite and ant activity closer to the Black Volta River than further up in the mountains.

This study was based on the assumption that burrows are a good index of aardvark abundance. Future studies should confirm the relationship between burrow density and population numbers.

Conservation concern

A dam is due to be constructed on the Black Volta River that will lead to the flooding of the area found to contain the highest density of aardvark burrows in Bui NP (Figure 5). This is likely to have a large impact on the aardvark population and, as aardvarks reproduce once per year, the population is likely to be slow to recover. The dam therefore represents a serious threat to the survival of the Bui aardvark population and the other species that depend on aardvark burrows for their own survival.

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Review

Extant hyrax diversity is vastly underestimated

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The Hyracoidea has fascinated naturalists for centuries due to their superficial resemblance to rodents (Sclater 1900) but morphological similarities to extinct South American ungulates (Shoshani 1991), perissodactyls (Sclater 1900, Osborn 1907, McKenna 1975, Fischer 1989) and elephants (Simpson 1945). Their affiliation to elephants and sea cows within the paenungulates has now been well established (Simpson 1945, De Jong *et al.* 1981, Kleinschmidt *et al.* 1981, Novacek & Wyss 1986, Shoshani 1986; see also Springer *et al.* 1999 and more recent papers on the Afrotheria). In addition to being somewhat of an oddity among mammals (Romer 1968), scientists have explored the unique morphological, physiological and behavioural adaptations of hyraxes for living in rocky and forest habitats across the environmental extremes of Africa and Arabia (see among others Sale 1965, Taylor & Sale 1969, Louw *et al.* 1972, Hoeck 1975, Stuart & Stuart 1984). Their taxonomy has also been hotly debated and numerous species and subspecies have been described. After many cycles of splitting and lumping, only four to five hyrax species are currently recognized: three tree hyrax species (*Dendrohyrax dorsalis*, *D. arboreus* and *D. validus*, but with some debate over the validity of *D. validus*), the bush hyrax (*Heterohyrax brucei*) and the rock hyrax (*Procavia capensis*) (Shoshani 2005, Figure 1).

Although the current taxonomy (Shoshani 2005) and some past treatments (e.g. Ellerman & Morrison-Scott 1951) regard *Procavia* as monotypic, others recognized four to five species within the genus (Allen 1939, Hahn 1934; Bothma 1971, Roche 1972, Corbet 1978). In more recent years these species have been treated as subspecies of *P. capensis* (Honacki *et al.* 1982, Meester *et al.* 1986), with *P. c. capensis* distributed throughout southern Africa, *P. c. welwitschii* occurring in northern Namibia and south-western Angola, *P. c. ruficeps* in north-west Africa (Gambia, Senegal, Ghana, Nigeria, southern Algeria, Cameroon, Chad, Sudan and the Central African Republic), *P. c. johnstoni* in Tanzania, central Kenya, Rwanda, Burundi and southern Uganda and *P. c. syriacus* extending from Kenya north-eastwards to southern Egypt, Israel, Syria and south-eastern Arabia (Figure 1A). Many past authors recognized three *Heterohyrax* species (Allen 1939, Roberts 1951, Bothma 1971, Roche 1972, Honacki *et al.* 1982, Meester *et al.* 1986), however, the previous reports of *H. antineae* in the Hoggar Mountains of south-eastern Algeria has recently

been contradicted and the northern limits to the distribution of *H. brucei* questioned (Hoffman *et al.* 2008). The formerly reported presence of *H. chapini* in the Loadi Hills in the Democratic Republic of Congo needs further investigation and the disjunct population of *H. brucei* in

Angola should also receive attention (Figure 1B). *Dendrohyrax* is limited to natural forests, with *D. arboreus* distributed in southern, central and east Africa, *D. validus* in eastern Tanzania and Zanzibar and *D. dorsalis* in central and west Africa (Figure 1C).

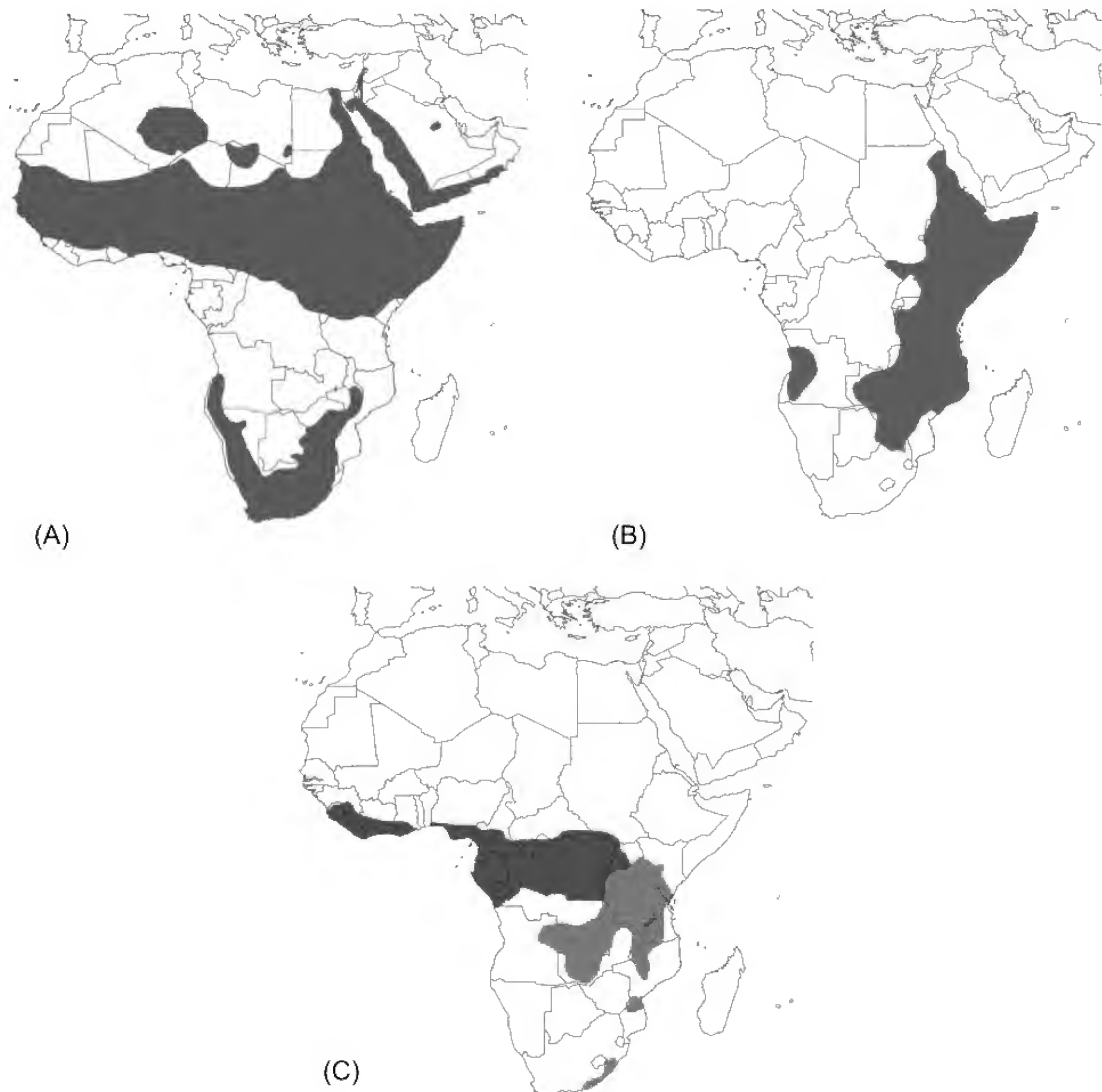


Figure 1 Distribution of the three hyrax genera across Africa and the Arabian region according to the recent Global Mammal Assessment (<http://www.iucnredlist.org/technical-documents/spatial-data>): (A) *Procavia*, (B) *Heterohyrax* and (C) *Dendrohyrax*. The outlines of different African countries are shown for easy reference to the text describing the distribution patterns as well as current and past taxonomic treatments. Three tree hyrax species are currently recognized: *D. arboreus* (yellow), *D. validus* (light green) and *D. dorsalis* (dark green). The recognition of single species of rock hyrax (*P. capensis*) and bush hyrax (*H. brucei*) should be revised.

Despite decades of taxonomic research on this unique group of important small mammalian herbivores (see amongst others Hoeck 1978, Olds & Shoshani 1982, Barry & Shoshani 2000, Shoshani 2005), their diversity remains enigmatic. The description of numerous subspecies in the past (Olds & Shoshani 1982, Barry & Shoshani 2000) and limited available molecular evidence (Prinsloo & Robinson 1992, Prinsloo 1993, Bloomer unpublished data) suggest that the diversity in the family is vastly underestimated. Not only do we urgently need to reassess this through multi-disciplinary systematic

research but we also have to accurately determine the geographic extent and status of each taxon. Recent reports of major hyrax die offs (personal communication received from various parts of South Africa; see also Ngoni 2002, 2005) might represent evidence of their natural population cycles, but the group deserves urgent wide-ranging research attention because we could be losing diversity before we have discovered it. Compared with research on their more famous cousins, they have been rather neglected over the past few decades.

What does the preliminary molecular variation suggest? We biopsied rock hyraxes and bush hyraxes throughout their ranges in South Africa and Matobo Hills in south-western Zimbabwe. Based on mitochondrial DNA (mtDNA) restriction fragment length polymorphisms (RFLP's; Prinsloo & Robinson 1992, Prinsloo 1993) and a small set of cytochrome *b* and control region sequences (Prinsloo 1993, Bloomer unpublished data), we found evidence of two distinct genetic groups within *P. capensis* and distinction of *H. b. ruddi* from *H. b. granti* (see Bothma 1964). The two rock hyrax groups occur in the south-west and north-east of South Africa and the latter group also extends to the Matobo Hills (Figure 2). Thus far we have never recorded the two groups in sympatry and our sampling to date allowed us to define the geographic boundary between them to within 10-20 km in the south and east; the boundary to the west is uncertain (Figure 2). The

geographic distribution of the two genetic groups in *H. brucei* largely agrees with Bothma's (1966) description of colour variation between the two subspecies; *H. b. ruddi* appears to be confined to the lower rainfall Limpopo River basin and extends to the Matobo Hills, while *H. b. granti* occurs in the higher rainfall areas of the Limpopo and north-eastern Mpumalanga Provinces of South Africa (Figure 3). Bothma's (1966) colour intergrades from the Soutpansberg and Blyde River regions all genetically group within *H. b. granti*. We could not adequately assess intraspecific variation in the tree hyrax (*D. arboreus*) due to the availability of a limited number of samples from Eastern Cape forests. However, samples from forests 150 km apart had two distinct mtDNA lineages and it is likely that isolation between forest patches played a significant role in generating diversity within this rare species.

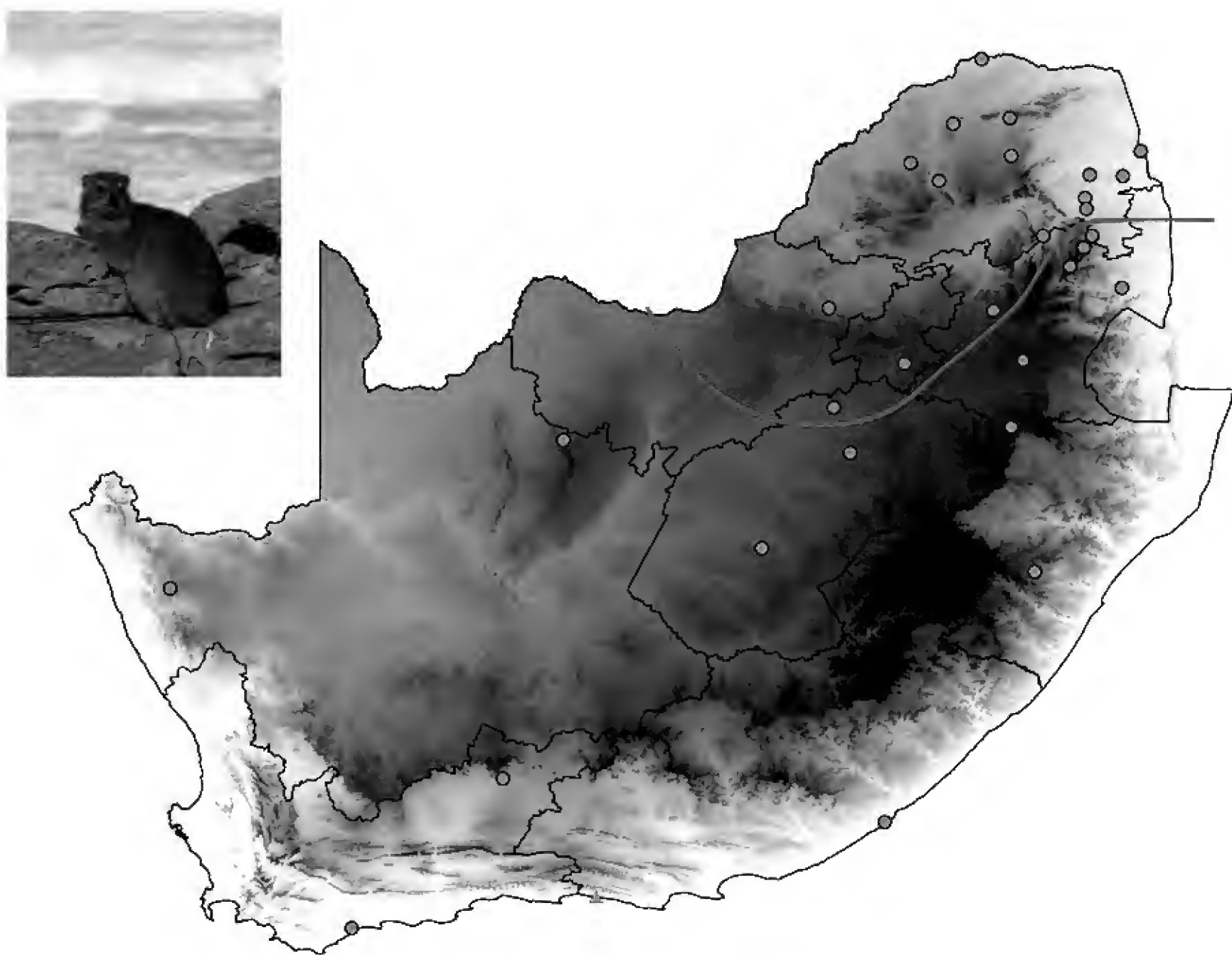


Figure 2 Map of South Africa indicating the distribution of the two rock hyrax genetic groups. Dots indicate the sampling localities. The northern group also extends to the Matobo Hills in south-western Zimbabwe. The photo (P Bloomer July 2009) is of an individual of the south-western group at the Tsitsikamma National Park (triangle) on the south coast.

We compared the South African hyrax DNA sequences to material we obtained from Israel (*P. c. syriacus*) and Kenya (*H. brucei*) (Bloomer unpublished data) and to existing published sequences of *P. c. johnstoni* (GenBank accession number D86904, Ozawa *et al.* 1997). More recently we included a rock hyrax specimen from northern Namibia. These sequences confirm the extent of variation in the two rock dwelling genera. For example, the Namibian sample genetically clustered closest to the south-western *P. capensis* from South Africa, although based on distant sightings and photographs it

morphologically resembled *H. brucei* (Galen Rathbun and Hendrik Hoeck personal communication). The two South African *P. capensis* (formerly *P. c. capensis*) groups are as distinct from each other as they are to *P. c. johnstoni*, and as the latter is to *P. c. syriacus*. *H. b. ruddi* is more closely related to the East African *H. brucei* (presumably *H. b. bindi*), than to the South African endemic *H. b. granti*. The latter taxon is of special conservation concern as it has consistently been observed in low numbers during the course of our research over the past 20 years.

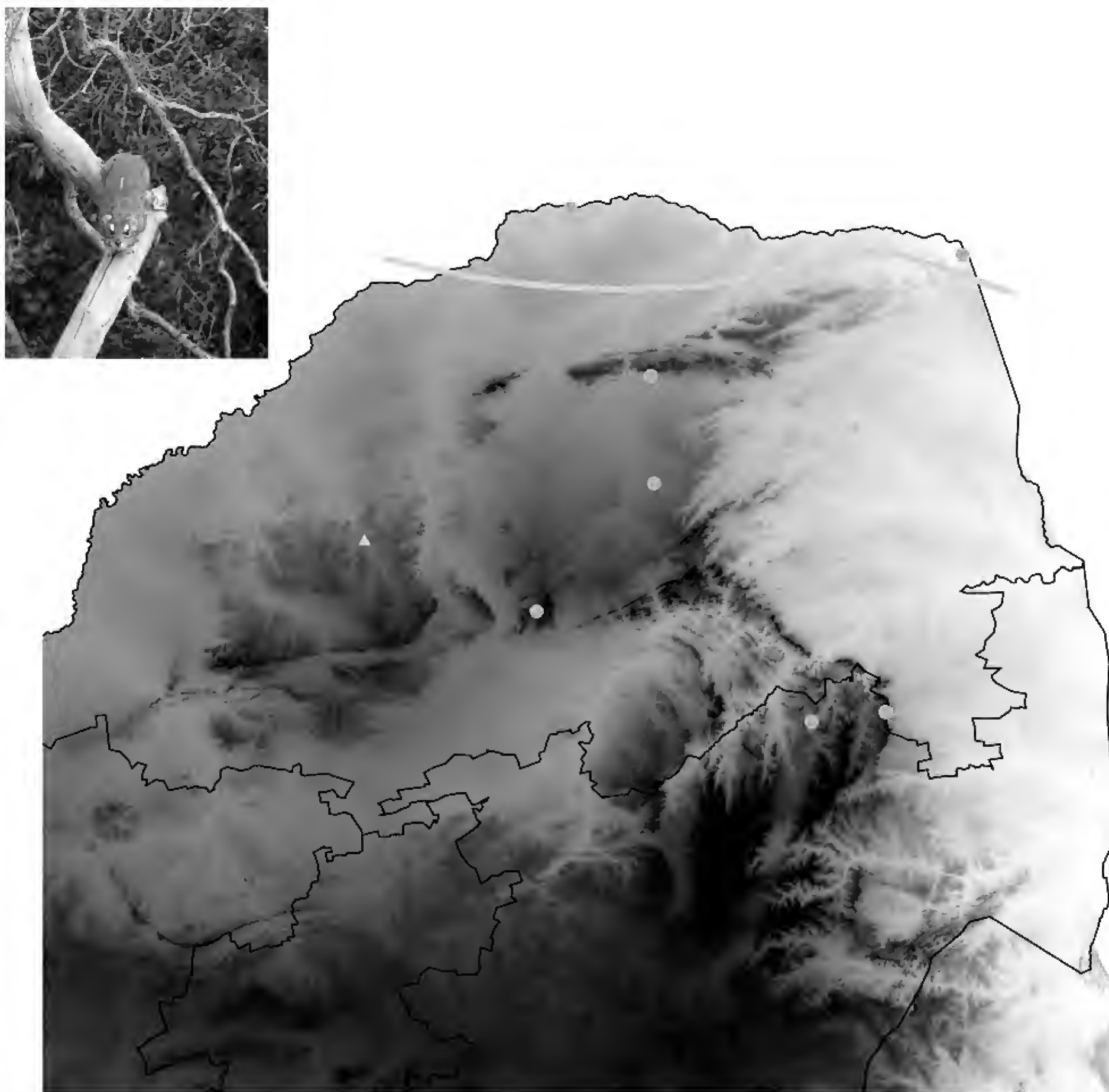


Figure 3 Map of the north-eastern parts of South Africa indicating the distribution of the two bush hyrax genetic groups. The dots indicate the sampling localities in the Limpopo and Mpumalanga Provinces. The northern group also extends to the Matobo Hills in south-western Zimbabwe and largely coincides with the distribution of the subspecies *H. b. ruddi*. The southern group corresponds with the subspecies *H. b. granti*. The photo (P Bloomer February 2007) is of an individual of the southern group from the Lapalala Wilderness Area (triangle) in the Waterberg region of the Limpopo Province.

We are currently extending these mtDNA data through the analysis of nuclear DNA intron sequences. We also plan to use microsatellite loci to study gene flow among hyrax colonies and populations. Gerlach and Hoeck (2001) already applied a few microsatellite markers to east African rock and bush hyraxes and additional hyrax-specific loci are currently under development (Lee Koren personal communication). These markers will enhance our ability to document gene flow processes in hyraxes and more accurately define species and localized conservation units.

This review serves as an urgent call for the contribution of hyrax material for further genetic analyses. We need to analyze material representative of the complete range of these taxa. Small ear biopsy samples are adequate for DNA extraction and interested parties can contact me for sampling instructions and

storage solutions. In addition, we also need further field observations, photographic material as well as sound recordings of the calls of all three genera throughout Africa. Voucher specimens tied to these photos, tissues and vocalizations should be deposited in regional natural history collections to allow a thorough taxonomic reassessment of this enigmatic family.

Acknowledgments

I wish to thank Terry Robinson for introducing me to these wonderful critters and for funding my PhD research (1989-1993). I would like to extend a special word of gratitude to Hendrik Hoeck who served as the hyrax coordinator since the inception of the Afrotheria Specialist Group and all the past members of the team; I hope we can significantly extend our knowledge and con-

servation actions for this group over the next few years. I thank everyone who assisted me with sample collection during my PhD and during more recent field collecting; I thank Abram Haim for rock hyrax from Israel, Koos Bothma for bush hyrax from Kenya and Galen Rathbun for rock hyrax from northern Namibia. Antoinette Meyer and Isa-Rita Russo generated sequences over recent years. I thank Mark Keith and Michael Hoffman for providing digital elevation maps and distribution information respectively, and Arrie Kloppe for generating the GIS maps for this article. PJ Stephenson, Galen Rathbun and Hendrik Hoeck provided valuable comments on an earlier draft of this article.

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Afrotheria News

Grey-faced sengi research update

The grey-faced sengi (*Rhynchocyon udzungwensis*, Figure 1) was recently described (Rovero & Rathbun 2006, Rovero *et al.* 2008) as the fourth species in the genus of giant sengis (Rathbun 2009). The new species is endemic to two separate, remote, and relatively small montane forests in the Udzungwa Mountains of south-central Tanzania (Figure 2), thus little is known about its biology. However, based on data from foot surveys and camera trapping, the new sengi has been classified as Vulnerable (Rovero & Doggart 2008), with its probable low population numbers vulnerable to stochastic events and the loss of forest habitat due to human activities (Rovero *et al.* 2008).



Figure 1. Captive adult grey-faced sengi, *Rhynchocyon udzungwensis* (photo F. Rovero).

With the discovery of the new sengi, several fascinating research questions became evident. For example, what is the evolutionary history of this species, especially in relation to the surrounding and more widespread chequered sengi (*R. cirnei*)? Does the distribution in relation to other giant sengis (Rathbun 2009) indicate an ancient origin or a more recent secondary derivation? The peculiar distribution also raised the need for a better understanding of its ecology and behaviour, including its home range, activity patterns, density, and population dynamics.

Thanks to a grant from the National Geographic Society, and co-funding from Italy's Museo Tridentino di Scienze Naturali, and the collaboration of colleagues Silva Ricci (Trento Museum), Galen Rathbun (California Academy of Sciences) and Cristiano Vernesi (Edmund

Mach Foundation, Italy), we developed a research project that involves two main components: a genetic analysis of the new species and its relatedness with *R. cirnei*, and a better understanding of the distribution and habitat preferences of the new species. Our research is currently at the final stages of data analysis.

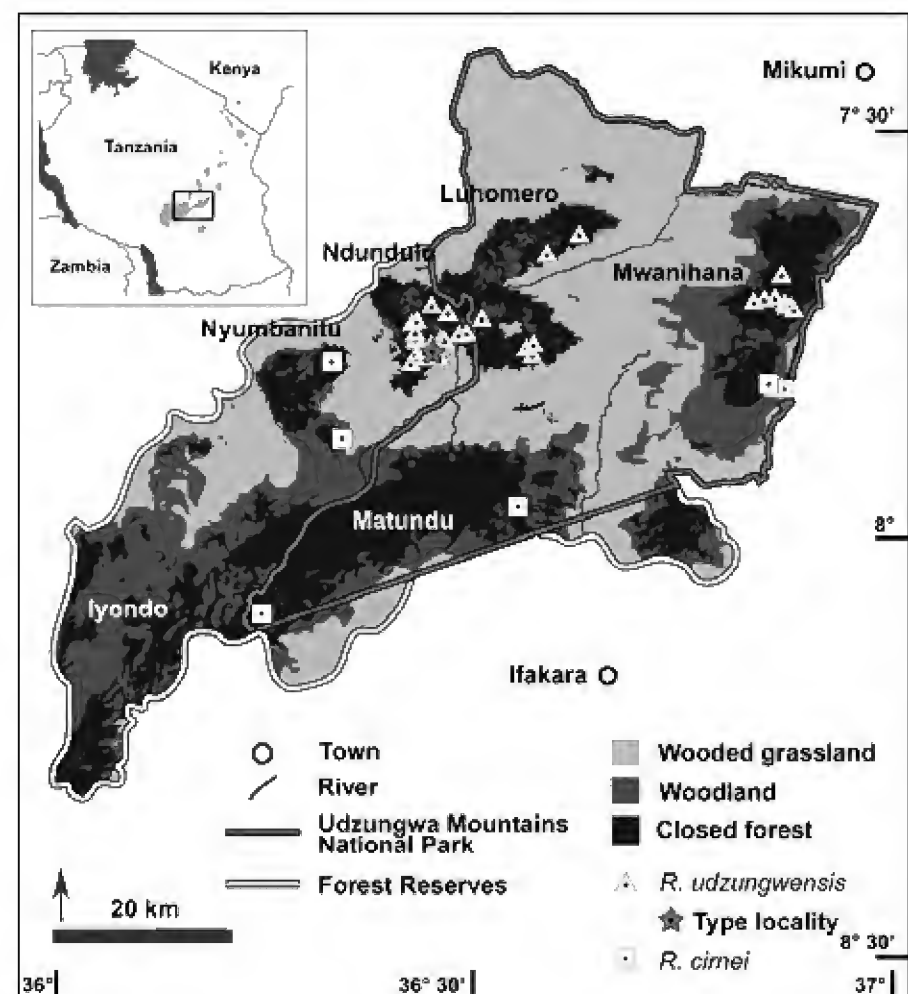


Figure 2. Distribution of *Rhynchocyon cirnei* and *Rhynchocyon udzungwensis* and their habitats in the Udzungwa Mountains, Tanzania (from Rovero *et al.* 2008).

In order to obtain DNA samples, we fine-tuned trapping methods using a combination of nylon snares, nylon fishing nets, and live box-traps. Nylon snares set on sengi trails by an experienced local field assistant, Ruben Mwakisoma, were successfully used when initially trapping for voucher specimens to describe the species. Fishing nets strung vertically along the forest floor have been successfully used for other giant sengi species, but surprisingly and inexplicably they have not worked on the grey-faced sengi. Instead, we have successfully used Tomahawk wire mesh live-traps set along trails. This method has the considerable advantage of not injuring the sengis (Figure 3). Overall, we have collected DNA samples from 17 *R. udzungwensis* from both populations, and eight of *R. cirnei*. The samples are now being analysed by Cristiano Vernesi's genetic lab.

We conducted extensive foot surveys and deployed camera-traps at about 40 sites to better understand the distribution of the new sengi. We mainly focussed our efforts in the eastern forest at Mwanihana, where the question of proximity to, or even overlap with, *R. cirnei* needed clarification. We also surveyed the Luhomero area to the west. We have found that the two species do not overlap, although distributions come very close at a relatively small area of central Mwanihana. The grey-faced sengi is found at higher elevations than the chequered sengi. At several camera-trap points, we measured canopy cover and density, as well as the diversity of understorey trees and forest floor cover, to quantify habitat preferences. This technique has recently been used on small forest-dwelling antelopes (Bowkett *et*

al. 2008). These data are currently being analysed.



Figure 3. Ruben Mwakisoma and Francesco Rovero taking body measurements from a live-trapped *R. udzungwensis*.

We have also just learned that an application to fund research on the behavioural ecology of the grey-faced sengi using radio-tracking methods has been funded. We hope our current and future research will shed light on the evolutionary history and ecology of this fascinating and recently found creature. This information will also help address conservation concerns.

Francesco Rovero

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Galen Rathbun

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Editors Note: Additional information on the discovery of this giant sengi and the methods used to capture giant sengis can be found on our group's web page by going to the sengi section and then "current topics".

New project on developmental morphology of mammals

There is a new project underway focusing on afrotherians and xenarthrans, entitled "Developmental morphology of southern placental mammals".

Deciphering the evolutionary tree of living mammals represents a major advance in biology, enabling the articulation of new hypotheses relating to mammalian evolution. For example, during the past few years it has become clear that two groups currently most common on southern continents - afrotherians (elephants, sea cows, hyraxes, armadillos, sengis, golden moles, and tenrecs) and xenarthrans (sloths, armadillos, and anteaters) - comprise the first branch diverging from the placental mammal Tree of Life. Intriguingly, these "southern placentals" show a high degree of developmental distinctiveness, including late eruption of permanent teeth, variable vertebral count, and (possibly) a high frequency of vertebral anomalies. The newly-recognised position of southern placentals on the Tree of Life may point towards a major biological discovery, namely, that a distinctive pattern of development separates these species from other placental mammals.

We seek to determine if a developmental dichotomy marks placental mammals by collecting anatomical data at key growth stages in southern placentals. Using established methods in comparing the development of phenotype across species, combined with already-documented patterns of growth in marsupials and "northern" placental mammals, we will investigate ossifications in cranioskeletal elements and formation and eruption of teeth.

Intriguing differences in the developmental anatomy of southern placentals exist relative to other mammals. Our investigation will indicate whether or not these differences are comprehensive for a large radiation, or are specialisations within individual afrotherian and/or xenarthran groups. If the former, the data on developmental sequences and vertebral anomalies that we propose to collect will determine if these differences are derived for the clade uniting southern placentals or, alternatively, if the apparent conservatism of all other placental mammals is itself a derived feature. Studies of comparative morphology and genomics are now at a stage where specific questions concerning selection on particular genetic loci may be addressed. For example, if afrotherians and/or xenarthrans can be characterised by morphological anomalies in the vertebral during development, might we detect a divergent level of selection at corresponding vertebral patterning loci in the Hox cluster among living afrotherians? Similarly, if the common ancestor of southern placentals is also characterised by a delayed eruption of the permanent dentition, might the Runx2 transcription factor, known to influence phenotype such as delayed eruption in human cleidocranial dysplasia patients and mouse mutants, also show a change in the level of selection at the relevant node(s) among southern placentals? The capacity to understand genetic regulation requires detailed information on phenotype, particularly in a developmental context, which is what our research will provide.

Robert Asher

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Aardvark death in Frankfurt Zoo

Sad news from Germany for Afrotheria watchers - the female aardvark in Frankfurt Zoo died earlier this year. The animal was named, Rosa, and was the mate of Elvis, the individual that appeared in the 2006 edition of this newsletter (*Afrotherian Conservation*, 4: 6).

Rosa (registered as studbook number 69) was born in the zoo in 1993. She was a first generation (F1) birth, daughter of "Miss Piggy", a wild caught female who had 11 offspring in captivity and lived to the age of more than 20 years. Rosa had 7 offspring herself.

Rosa died at the age of 16. The zoo is not yet sure of the cause of death.

Although sad news for the zoo, a detailed examination of Rosa's body will allow us to learn more of the anatomy of this poorly studied species; the last anatomical study was done in the 1920s.

Thomas Lehmann

Wissenschaftlicher Mitarbeiter

Abteilung Paläoanthropologie und Messelforschung

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IUCN Red List training workshop held in Argentina

Nestled at the foot of the majestic Andes Mountains, lies the colourful and vibrant city of Mendoza, home to the pink fairy armadillo, the condor and the warm and powerful "sonda" winds. It was here where novice and experienced mammalogists from around the globe united to receive hands-on training in Red List Assessments and the Species Information Service (SIS) software, as part of the 10th International Congress of the Federation of Mammalogists. The workshop was organized and presented by Dena Cator and Caroline Pollock on behalf of the IUCN Species Survival Commission. They were assisted by chairs of SSC specialist groups. Congratulations Dena, Caroline and the team for your efforts in co-coordinating a stimulating and highly informative experience...obrigado!

The endeavour entailed a Red List training workshop on Sunday 9 August followed by a session on 12 August where the SIS software was demonstrated and used. The training workshop kicked off with Caroline Pollock's short history of red listing work and the role of the Red List Unit in IUCN. The workshop objectives were: 1) To improve understanding of the meaning of the terms used in the Red List Categories and Criteria, 2) To provide training on how to apply the IUCN Red List Categories and Criteria to produce good-quality assessments suitable for inclusion in the *IUCN Red List of Threatened Species*, 3) To provide training on how to apply the IUCN Red List Categories and Criteria for regional level assessments to produce good-quality assessments suitable for inclusion in a regional (e.g. continental, national) Red List.

Dena Cator provided us with a thorough step-by-step grounding in the nature, role and application of the different categories of risk (Critically Endangered, Endangered, Vulnerable) as well as the appropriate use of the Near Threatened, Data Deficient, Extinct, Extinct in

the Wild, Not Evaluated and Least Concern categories, as per the latest adapted version (IUCN 2004. *IUCN Red List Categories and Criteria: Version 3.1*. IUCN Species Survival Commission, Gland, Switzerland). The taxonomic level and scope of the categorization process was also clarified when assessing extinction threats. The five criteria used to evaluate if a taxon belongs to a threatened category (population reduction, geographic range, small population size and decline, very small or restricted population and quantitative analysis) were also dealt with in detail using a range of quantitative criteria. Data quality and the importance of inference and projection, problems of scale, conservation actions in the listing process, uncertainties, implications of listing, the importance of documenting all assessments, re-evaluation, transfers between threat categories, threats and priorities and the use of the categories at a regional scale were also emphasized here.

The afternoon session constituted an interactive session that provided an opportunity to gain invaluable practical experience in the application of the categories and criteria to case studies selected by IUCN. The groups were tasked with evaluating the status of at least two species on the list using the updated one-page summary sheet under guidance of a presenter or the chair of a Specialist Group. This demonstrated how the *IUCN Red List Categories and Criteria version 3.1* should be applied to a number of different taxa. To broaden the range of species with different life histories, each group focused on determining the extinction risk of at least one species of interest to a workshop participant (e.g. pink fairy armadillos and African golden moles). A feedback and discussion session enabled members of other working groups to submit comments, suggestions and alternative opinions on evaluations and threat assessments.

At the second workshop, Caroline Pollock gave a brief introduction to IUCN's SIS. The workshop objectives were: 1) To provide training on how to use the IUCN SIS, 2) To improve understanding of the documentation requirements to support good-quality Red List assessments for inclusion in the *IUCN Red List of Threatened Species*. The demonstration of SIS software included sessions on start-up requirements, navigating species and assessments, taxonomic and assessment information and working sets, which were practiced and tested in two practical afternoon sessions.

All relevant documentation and software were immediately available from the organizers and for the duration of the congress from the IUCN booth. Hard copies of relevant documentation (e.g. summary sheet, truncated booklet of Red List Categories and Criteria and case studies) were provided, and electronic copies were distributed to participants within two weeks of the workshop. This was invaluable for in-depth follow-up self training for novice and experienced users alike.

At the end of each intense day of listening, learning and practical experience, the prospect of good food, excellent Malbec or Cabernet Franc enjoyed with old and new friends that share a common passion was a pleasant one. Somewhere among the laughter and the roar of an old-time automobile, an accordion was playing a Carlos Gardel tango.

Sarita Maree

Department of Zoology and Entomology, The University of Pretoria, South Africa.

Afrotheria Specialist Group revamps its newsletter

The IUCN/SSC Afrotheria Specialist Group published six editions of *Afrotherian Conservation* between 2002 and 2008. In July-August 2009 the newsletter's editor, PJ Stephenson, conducted a review to determine how readers and group members felt the publication could be improved. Feedback from 40 respondents showed general approval of the aim, format, content and frequency of the newsletter, with a clear preference for sections that profile target species and list the latest publications. Proposed improvements included more review articles, progress reports on conservation and research projects, more French articles, and more illustrations and photos. Members also want to receive information on funding and job opportunities.

The full report on the newsletter review, as well as all previous editions of *Afrotherian Conservation*, can be found on our group's website at:

<http://afrotheria.net/newsletter.html>

We have done our best to start addressing some of these recommendations in this edition. Meanwhile, please contact me directly if you have any further feedback or ideas for improving our newsletter.

PJ Stephenson

Editor, *Afrotheria Conservation*

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The Afrotheria Specialist Group gets a new web address

When we formed our specialist group our web master at the time, Erik Seiffert, worked closely with the then California Academy of Sciences web master Charles Fox to develop our web site. It has served us very well over the years, thanks to both of their efforts. Things change, however, and the Academy is implementing some significant changes to the way they manage material on their web site, which necessitated some long-range planning on our part, in terms of our web site. The academy and I have decided to move our web material to our own address or URL, where Charles Fox will continue to help us keep it current.

The new URL is <http://www.afrotheria.net/>

In addition to the usual updates and fine-tuning of the material at our new address, we have added a new menu option: "Donations, Please". With our own web address, we now have yearly recurrent expenses for the URL and server, and their maintenance. I hope all readers will be able to donate a modest amount towards the site maintenance. Many thanks in advance for your support!

Some years ago Erik Seiffert became focused on his professional career and job security and was unable to actively participate as web master. With the help of Charles Fox at AvianDesign, I have limped along since then. Our web site would greatly benefit from a web-

savvy specialist group member taking on the web weaving! Please let me know if you are warm and willing!

Galen Rathbun

Chair, IUCN-SSC Specialist Group

Noticeboard

Photographic map for hyraxes (Procavidae)

In order to gain insight into the diversity of the phenotypic characteristics and loud calls of hyraxes (Procavidae) throughout their geographic ranges, we designed a map ('Hyrax Photomap') that is linked to photographs and to sources to contact for recordings of loud calls. Hyrax Photomap serves as a 'living' photographic and audio collection --- a tool we earlier designed for the primates and warthogs of East Africa (www.wildsolutions.nl). Anyone with an interest in hyraxes can use this resource, add their hyrax photographs, announce that they have audio recordings that are available for use by others, and provide observations, comments, references, and other information.

The expectation is that Hyrax Photomap will become increasingly useful as the number of photographs, audio recording, and information base grows. To access Hyrax Photomap, go to <http://picasa.web.google.com/lh/view?uname=wildsolutions&cuname=wildsolutions&tags=Hyrax#> or www.wildsolutions.nl. Clicking on a particular photograph will cause it to enlarge and related information will appear (e. g. species name, location, vegetation type, altitude, vocalizations). The locality of the photograph/recording will appear on a Google map on the right side of the screen (Figure 1). An overview of all photographs/audio localities can be readily accessed by clicking on the 'View Map' link in the lower right corner (immediately under the small map). The viewer can leave a comment with any photograph or audio entry (if s/he is a member of Google) by clicking the comment button for that photograph/audio entry). Audio recordings can not be downloaded from Hyrax Photomap directly, but a request can be made, via email, to the person who holds the recording.

To make Hyrax Photomap as complete and useful as possible, we invite you to send us your photographs and/or audio recording details of hyraxes. For each photograph, please include as much detail as possible...most importantly the species name (or likely species), locality where the photograph was taken, coordinates (or describe the location so that we can plot it on the map), elevation, date, and whether you made audio recordings at the site. The more details the better...so please describe the vegetation, the call, etc.

Unfortunately, audio recordings cannot be uploaded onto Hyrax Photomap. If you have hyrax vocalizations to share, please send us the locality details (not the actual recordings) and we will add a dummy image to the map to show the viewers that there are recordings available from you for this locality. Again, add as many details as possible.



Figure 1. A screen shot from the Hyrax Photomap.

If you have any suggestions, questions or comments, please contact us. Photographs (not larger than 2 MB) can be sent by email to yvonne@wildsolutions.nl or on CD by airmail to the address below.

Yvonne A. de Jong & Thomas M. Butynski

Eastern Africa Primate Diversity and Conservation Programme, P. O. Box 149, 10400 Nanyuki, Kenya.
yvonne@wildsolutions.nl or wildsolutions@gmail.com

How is membership in the Afrotheria Specialist Group decided?

When we set up the IUCN/SSC Afrotheria Specialist Group nearly 10 years ago, several of the initial organisers discussed what criteria should be used to invite members. There were several models available, from an "open to all that have any interest" at one extreme, to only those that had "demonstrated expertise" on "our" afrotheres (usually publications), at the opposite extreme. Because we wanted our specialist group to provide expertise (see our mission statement on our web site), we decided on the latter model. Another factor was that none of us, as volunteers with other jobs, wanted to spend our time administering a huge membership, given the emphasis on *specialist* rather than *interest* for our group.

We decided to partially decentralize the leadership of our group, from the more common "all-powerful" single chair, to a group of co-ordinators for each clade (see our membership list on our web site), with the role of the chair being one of leadership - providing momentum, direction, and coordination for the group. The decentralized organization avoided the potential problem of one person not being able to fully grasp all the issues related to such a diverse group of mammals as the Afrotheria, and also to disperse the work load among several volunteers.

Another factor in choosing members was the desirability to include African nationals in our group, but

at the same time not compromise our decision to keep the group membership lean and restricted to demonstrated experts. Related to this, we have tried to avoid overloading the membership with too many people from any one region or country - this especially has been a problem with regard to South Africa, Kenya, Europe, and the US.

In a few cases, we have deviated slightly from the above membership criteria. For example, a few of our members do not have species expertise with "our" afrotheres, but they are familiar with a region and are experts on important habitats, especially those that support species that have a threatened status (see the conservation page of our web site).

Lastly, as Chair I have taken the responsibility of trying to ensure that all our members remain involved with the activities of our specialist group. If not, I have not re-appointed them at the start of each quadrennial. Of course inactivity is often due to factors that are completely understandable and beyond the control of some individuals, such as job or interest changes or particularly heavy job responsibilities that preclude donating time to our specialist group (and please remember, we all serve as volunteers).

Although we are a specialist group in the strict sense of the work, we also realize that in some respects we serve as an interest group. To try and better serve this more generalized community of people, we encourage participation in our newsletter by non-members. To further meet the needs of non-members, we maintain an email list for general announcements and information related to our newsletter and web site.

Galen B. Rathbun

Chair, IUCN/SSC Afrotheria Specialist Group

Funding opportunity for specialist groups

The Chicago Zoological Society is soliciting new pro-

posals for the Chicago Board of Trade Endangered Species Fund for the first grant Cycle of 2010. The deadline is 1 March 2010 (early submissions welcome).

In general, the CBOT Committee wishes to have grant funds applied to projects that will assist directly in the protection of populations of endangered animal species that fall into the IUCN categories of Vulnerable, Threatened, Endangered and Critically Endangered Species (IUCN Red List Status) or a specific habitat that is of high biological value or that is substantially threatened. This includes projects that will quantitatively assess population and environmental status with indications of the best conservation strategy; projects that will help achieve sustainable relations between local people, and have a clear impact on the local developing conservation community and the species of concern. The development of educational projects and training that assist in building local conservation capacity are given higher priority.

Grants are open to SSC Specialist Group Chairs and Officers, AZA/WAZA Chairs and Officers, and all interested conservationists. Each group should review and submit only one proposal that has been ranked as the highest funding priority and endorsed by the group. The Fund will support small projects usually up to \$5,000 (smaller requests will fare better).

Members of the IUCN/SSC Afrotheria Specialist Group should contact the group chair, Galen Rathbun, directly if they are interested in applying. Other potential applicants can get more information, including more detailed application information, from Carla Owens Manager, Library Services & Archives, CZS CBOT ESF Administrator. Email: cbotesf@czs.org.

Abstracts

Diversity in sengis

Rathbun, G. B. 2009. Why is there discordant diversity in sengi (Mammalia: Afrotheria: Macroscelidea) taxonomy and ecology? *African Journal of Ecology*, 47: 1-13.

The seventeen species of sengis or elephant-shrews form a well-defined clade of mammals endemic to Africa that occupy the extremes of terrestrial habitats, from coastal deserts to montane forests. Because of their isolation on Africa soon after the break-up of Gondwanaland, theoretically sengis initially evolved with little competition from other placental radiations. Their life history features include myrmecophagy, saltatorial gaits, no or limited use of nests, social monogamy, small litters of precocial young and absentee maternal care of neonates. These traits together are unique to the Macroscelidea and represent a wedding of features usually associated with either small antelopes or anteaters. Combined, these features define an adaptive syndrome that presumably has been relatively immune to competition from contemporary mammals, partially due to phylogenetic inertia. Yet paradoxically, the syndrome is well suited to a wide range of terrestrial habitats, resulting in low taxonomic diversity. Because of their unusual phylogeny and low species diversity, conservation interest is high for those sengis with relatively low densities in fragmented forests.

Another new tenrecs species

Olson, L.E., Rakotomalala, Z., Hildebrandt, K.B.P., Lanier, H.C., Raxworthy, C.J. & Goodman, S.M. 2009. Phylogeography of *Microgale brevicaudata* (Tenrecidae) and description of a new species from western Madagascar. *Journal of Mammalogy*, 90(5):1095–1110.

A new species of shrew tenrec (*Microgale*) is described from the central western and southwestern portion of Madagascar. Based on pelage, morphology, and DNA sequence data, this new species can be readily distinguished from its sister taxon, *M. brevicaudata*. Mitochondrial DNA (mtDNA) divergences between the 2 species are on par with those observed in other closely related shrew tenrecs, and both taxa are recovered as reciprocally monophyletic haplotype clades. Furthermore, mtDNA sequence obtained from the holotype of *Paramicrogale occidentalis* confirms that the name *occidentalis* cannot be assigned to the new taxon and is a junior synonym of *M. brevicaudata*. *Microgale* new species and *M. brevicaudata* have latitudinally overlapping distributions, and although they are not known to occur in direct sympatry, specimens of both species have recently been collected at sites within 50 km of each other on opposite sides of the Soahany River in central western Madagascar. However, the respective distributions of these 2 species, among the most diminutive of Madagascar's endemic terrestrial mammal fauna, suggest that rivers do not serve as significant barriers to dispersal. Historical demographic analysis under a coalescence framework suggests that the northerly distributed *M. brevicaudata* has experienced a recent population expansion, whereas the new species described herein has undergone a population decline. Little is known about the ecology of *Microgale* new species, but it lives in dry forest formations. This species is known from sites within several protected areas (Bemaraha and Namoroka), as well as forest parcels currently proposed as new conservation zones. However, toward the southern limit of its known distribution, at the north bank of the Onilahy River, there is continued extensive anthropogenic habitat loss that may warrant future monitoring.

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A greater hedgehog tenrec, *Setifer setosus*.

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